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INVESTIGATIONS DIRECTED TOWARD DEVELOPMENT OF A DIRECT READING THICKNESS GAGE FOR PAINT FILMS ON WOOD

By

F. W. Brown, III and R. L. Alumbaugh

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INTRODUCTION

The laboratory test model of a paint film thickness gage previously described,[1,2] was used to establish the feasibility of the beta-ray backscattering technique to measure the thickness of paint films commonly applied to wood. Results were consistent with the theoretical predictions, and experimental evidence indicated that the construction of a more rugged field model was needed. This report presents the results of the final two phases of the work, namely: Phase I, the design and construction of a portable field model gage of improved characteristics for the collection of additional laboratory data and for limited field testing; and Phase II, a report of efforts directed toward the design and construction of a direct reading paint thickness gage for wood.

Preliminary tests indicated that the backscatter method may not be as generally applicable to paints on masonry surfaces as for those on wooden substrates. This is because the difference between the effective atomic number of commonly used masonry paints and their masonry substrates is not as great as is the difference between paints and their wooden substrates.

PHASE I - THE PORTABLE PAINT FILM THICKNESS GAGE

Design and Construction Considerations

The design and construction of a more rugged but easily portable paint film thickness gage required consideration of several materials for fabrication of the probe. Because of the requirement for light weight and impact resistance, plastic materials were selected to hold the Sr-Y-90 source and to house the Geiger-Mueller tube. The geometry of the probe was essentially the same as that of the laboratory model described earlier;[2] i.e. the source of radiation, Sr-Y-90, was mounted coaxially with the Geiger-Mueller tube. A brass safety shield was used as a protective cover over the source when not in use.

The portable gage and its protective cover are shown in Figure 1; Figure 2 presents both the gage with the protective cover removed and the counting rate meter. This counting rate meter was used instead of a scaler so that readings could be taken on backscattered beta radiation in the field with portable, easy-to-use equipment. In comparison to a scaler, a counting rate meter has an inherent disadvantage in measuring radioactive disintegration rates; if a practical time constant is used in the integrating circuit, the timewise variations of the

measured intensity are large enough to make reading of a representative disintegration rate difficult. A trade-off has to be made between the time of response and the accuracy desired. In the portable gage constructed here, the time constant is about 15 seconds (time to reach 1/e of the average reading, where e is the base of natural logarithms, or 2.7182818...). The time to reach practical equilibrium is about one minute. This is almost as long a time constant as is practicable, but it is not long enough to give the desired accuracy for paint films of greater thickness than 12 to 15 mils. An experienced person can average these fluctuations by eye, but this is not desirable in an instrument for the inexperienced. This version of the gage can give results accurate to about 5 percent of paint film thickness by careful measurements, which is the accuracy of most gages used to measure paint thicknesses on steel.

Laboratory Calibration

The counting rate meter gives a reading proportional to the true counting rate rather than reading directly in counts per minute. The various paint samples previously described as reference standards[2] were measured with this new portable gage, and the results given in Table 1 were used to prepare the calibration curves shown in Figure 3. As in the earlier investigations, the log of the differential counting rate is a linear function of the paint thickness[1,2], i.e.

$$\ln\left(J_{max} - J_d\right) = A - Bd$$

or

$$\ln\left(J_d - J_{min}\right) = A - Bd$$

where

J_d = intensity of the backscattered radiation, counts/min

J_{max} or J_{min} = backscattered counting rate from an infinitely thick paint film

d = thickness of paint film, cm

A and B = constants combining the other fixed parameters

For additional information on other theoretical considerations, see reference 2.

Field Testing

Use of the portable paint film thickness gage for field measurements of paint thicknesses on wooden structures yielded good results. Measurements were made on base housing at the Construction Battalion Center,

Port Hueneme, California, at Moffett Field, and at Treasure Island Naval Station, California, and on the wood trim of a building at the Public Works Center, San Diego Naval Training Center, San Diego California. The houses and buildings at Port Hueneme and at San Diego were coated with one coat of TT-P-102. Readings with the paint gage indicated film thicknesses of 1-1/2 to 2-1/2 mils, which is consistent with that expected for one coat of TT-P-102.

The contracts on the Moffett Field housing called for one coat of TT-P-25 primer and two coats of TT-P-102 finish, which should give 4 to 6 mils total dry film thickness. The paint film thicknesses determined with the gage were generally found to be 4 to 5 mils. However, gage readings indicated that the paint film thickness of some of the units was only 1.5 to 2.5 mils. A qualitative visual comparison of the paint thicknesses made where the edge of the films were visible indicated that the gage readings were essentially correct.

The gage performed satisfactorily in these field tests; however, the tests showed that certain modifications would be desirable for a gage that is to be used by field personnel and these are discussed later in this report.

Effect of Moisture on Gage Readings

One of the requirements for the successful performance of a paint film thickness gage is that its readings not be affected by the change in moisture content of painted wood. The reason for this is obvious when one considers the vastly changing environmental conditions to which painted wooden surfaces are exposed. In order to determine if a change in the moisture content of painted wood affects the reproducibility of the gage reading, a series of painted and unpainted panels were exposed to four different humidity conditions, i.e. ambient (about 50%), 25%, 50% and 80% relative humidity. Because the panels were already conditioned at ambient humidity conditions, approximately 50% RH, they were exposed to the 50% RH room first for two days. This exposure was followed by 7 days at 25% RH, and up to 46 days in the 80% RH chamber.

The test panels consisted of uncoated controls of ponderosa pine and douglas fir and these same woods coated with two different systems. One of the painted series consisted of one coat of TT-E-545 primer (over ponderosa pine) topcoated with one and three coats of Paint A, an acrylic emulsion topcoat, System 4 in Table 1. A second series consisted of two coats of TT-P-102, oil base topcoat, applied directly to the douglas fir panels, System 1 in Table 1. The weight of the panels and paint film thickness gage readings were taken periodically and these are recorded in Table 2.

Reference to Table 2 shows that, although the weight of both the coated and uncoated wooden panels increased by 4 to [illegible] percent as the relative humidity was increased from 25 to 80 percent, the gage readings were essentially constant in all cases.

In addition to the above, an uncoated ponderosa pine panel and a douglas fir panel coated with four coats (9.5 mils) of TT-P-102 were immersed in water for two days. Although the weight of both panels increased about 25%, the gage readings again remained essentially constant. All of the above data indicate that water absorbed in the wood or coating film does not adversely affect the readings and particularly the reproducibility of the gage.

PHASE II - INVESTIGATIONS TO DEVELOP A DIRECT READING PAINT FILM THICKNESS GAGE

Gage Modifications

Laboratory and field studies carried out during Phase I suggested a number of modifications which would increase the utility of the paint film thickness gage. The most important modification or improvement suggested was the development of a direct reading paint film thickness gage. The reason for this is obvious, since a direct readout of paint film thickness would eliminate the requirement to carry calibration curves for each of the different specification systems used at Navy field installations. A direct reading gage would also eliminate one potential source of error, i.e. misinterpolation of the calibration curves.

Design of a direct reading paint film thickness gage could be approached in either of two different ways. One method is to develop a different electronic circuit for each different type of paint to be measured, each circuit being designed so that it can be used with the same linear scale to give direct readout of the paint film thickness; such a circuit arrangement would consist of a bank of current generators for fitting the calibration curve of J_d versus d, where d is the paint film thickness and J_d is the intensity of backscattered radiation. A switch on the specially designed meter would be used to select the appropriate circuit for the paint being measured. The other method would be to use a different mask for the scale of the counting rate meter calibrated to read d directly, for each individual paint.

In the first case only one linear scale would be used, but an untrained person might be misled in the relative accuracy of the meter readings because the error would be greater when measuring thick paint films than when measuring thin films. In the second case a different, replaceable scale would have to be used in the meter for each paint, and some field personnel would have difficulty in correctly interpolating between marked units on the logarithmic scale. Of the two, the first method appeared to be the more promising for field operations and was the method pursued in this work.

A second improvement would reduce the size of the gage probe. The portable paint film thickness gage has a probe diameter of 2-3/4 inches.

During the experimental use of the gage in the field it was found that a probe of smaller diameter, about 1 inch, would be desirable so that it could be used to measure paint thicknesses on wood trim. It was also considered desirable to construct the gage probe of stronger material; nevertheless, those parts of the probe below the detector must contain only low atomic number material to avoid extraneous background backscattering of beta rays. Development of a gage shield of thinner material (but thick enough to stop the beta radiation) would also be desirable to improve handling.

Preparation of Calibration Standards

Concurrently with development of the direct reading paint film thickness gage and the 1-inch diameter gage probe, it was necessary to prepare additional calibration standards for other exterior specification paint systems for wood which are commonly used at Naval field installations. Thus, in addition to those calibration standards already prepared and listed in Table 1, the following exterior specification paint systems were applied to douglas fir panels measuring 4 x 5-3/8 x 1/2 inch.

System 5 - TT-P-25 Primer Coating, Exterior, + TT-P-0019, Paint Acrylic Emulsion, Exterior (White Topcoat)

System 6 - TT-P-25 Primer Coating, Exterior, + TT-P-105a Paint, Oil: Chalk-Resistant, Lead-Free, Exterior Ready-Mixed, White (Topcoat)

System 7 - TT-P-25 Primer Coating, Exterior, + MIL-P-52324 Paint, Oil, Alkyd, Exterior, White (Topcoat)

System 8 - TT-P-25 Primer Coating, Exterior, + TT-P-102, Paint, Oil: Titanium - Lead-Zinc and Oil Exterior, Ready-Mixed, White (Topcoat)

System 8 contains the same topcoat as System 1 but is applied over TT-P-25 primer instead of directly to the wood as in System 1. System 8 was prepared for purposes of comparison.

The douglas fir panels were arranged side by side along the 10-ft length of a paint spray table so that all panels of each system could be coated at one time. For uniformity, all coatings were spray applied with an automatic transverse paint spray machine. Three 6 x 12 x 1/8-inch sandblasted mild steel panels, interspersed among the wooden panels, were coated at the same time. The metal panels were coated so that the actual thickness of each coat of paint applied could be determined using a conventional magnetic paint film thickness gage.

Since the primer was the same, TT-P-25, for all four systems, all panels were primed during the same painting operation. A set of panels coated only with the primer was removed for controls and the remaining primed panels were subsequently coated with one, two, three and four coats of their respective topcoats. The coated wooden panels were prepared in triplicate sets for each thickness of each system. Following application and drying of each of the topcoats, one set of panels was removed for each of these four calibration systems. The sets of triplicate panels were removed randomly to lessen any systematic errors that might arise during the painting operation. The surface of each metal panel was divided into five equal parts and masked. Thus, at the conclusion of the painting operation, each of the three metal panels for each system contained areas having one coat of primer and one, two, three and four coats of topcoat over the primer. The dry film thicknesses of the calibration standards determined using a magnetic paint film thickness gage are given in Table 3.

Prior to application of the topcoats, beta-ray backscatter readings were taken for all of the TT-P-25 primed panels using the portable gage shown in Figure 2. These values checked well both among themselves and with the previous readings that had been obtained for similar lead pigmented paints. After application of Systems 5 through 8 had been completed and the coatings had cured for about two weeks, gage readings were taken on all of the coated panels. These readings, which are the averages from the three replicate panels of each system at each thickness, are given in Table 3.

Reference to Table 3 shows a rather serious anomaly for the gage readings which was entirely unexpected. The beta-ray backscatter readings for Systems 5, 6 and 7 showed no appreciable change from the values for the primer alone, regardless of the type or thickness of the topcoat. All three of the topcoats (Systems 5 through 7) appear to be transparent to the beta rays and backscattering apparently occurred only from the primer. Of the four newly prepared calibration systems, only System 8, in which the topcoat contains lead pigmentation, gave readings which appeared to be approximately correct (e.g. compare readings for System 8 in Table 3 with System 1 in Table 1). At first it was thought that the anomaly might have resulted from a malfunction of the gage. However, repair of the gage did not change the readings appreciably.

A calibration curve for System 8, based on the data given in Table 3, is shown in Figure 4. Calibration curves for Systems 5, 6 and 7 were not prepared because gage readings were essentially the same, regardless of the coating thicknesses.

Development of the Direct Reading Gage and Small Probe

Preliminary circuit designs were prepared for a direct reading paint film thickness gage which incorporated the counting rate meter

shown in Figure 2 for readout. The design incorporated banks of current generators for fitting calibration curves of J_d versus d to a linear readout scale on the counting rate meter. (Calibration curves shown in this report, Figures 3 and 4, have J_{max} - J_d plotted versus d rather than J_d versus d because the former curves are easier to interpolate.) A breadboard model of this circuit design was prepared and necessary modifications were being made when the anomaly mentioned in the above section was first observed. Because of this, no further work was carried out on the breadboard model.

The smaller 1-inch diameter probe, which was designed and fabricated with essentially the same relative geometry as the larger probe, is shown in Figure 5. The source of radiation, Sr-Y-90, was not as strong as had been indicated by preliminary calculations. As a result, it could not be used with the same counting rate meter as that used for the larger probe (see Figure 2). It was planned to modify a second counting rate meter which was more closely matched electronically to the Geiger-Mueller tube of the 1-inch probe when the anomaly mentioned above was discovered. Because of this, no additional experimentation was conducted with the small probe.

DISCUSSION

Date presented in earlier reports[1,2] have demonstrated the feasibility of using the beta-ray backscattering technique for measuring the film thickness of specification paint systems applied to wood, i.e. Systems 1, 2 and 3. These are paints or paint systems commonly used at Naval shore installations. The utility of the gage was further demonstrated during Phase I, both in the laboratory and in the field, by the design, construction and use of a portable model that could be used for measuring film thicknesses of these same paint systems, primarily TT-P-102, applied to wooden buildings. The primary limitation at that point in the development appeared to be that the paint system being measured had to be known and calibration curves were required before any definitive measurements could be taken. It is believed that the latter limitation would have been overcome with the successful design and construction of the direct reading gage.

A much more serious deficiency was observed when calibration standards for additional paint systems were prepared. Thus, the gage readings for System 5 showed no appreciable change as different thicknesses of a specification topcoat over the TT-P-25 primer were added. The same phenomena occurred in Systems 6 and 7; that is, the topcoats appeared to be transparent to the beta rays.

The reason for this apparent transparency is not completely clear, although it may be associated with the fact that each of the specification topcoats, TT-P-19, TT-P-105, and MIL-P-52324, contain between 40 and 50 percent extender pigments. These types of pigments are relatively

light in weight and would not be expected to have a very high effective atomic number, which is one of the primary variables affecting the degree of backscattering for any given paint. The type and percent of pigment present in each of the calibration paints are given in Table 4.

Additional evidence that the extender pigment may be responsible for this apparent transparency may be seen by comparing the gage readings for Systems 2 (in Table 1) and 5 (in Table 3) and the pigment compositions for the topcoat of these two systems given in Table 4. Both systems have similarities. For instance, both use TT-P-25 lead pigmented primer, both are latex paints, and more important, both have titanium dioxide as the major pigment. However, the TT-P-0055 of System 2 has 90% titanium dioxide and 10% extender pigment while the TT-P-19 of System 5 has only 57% titanium dioxide with 37% extender pigment and 6% barium sulfate. The gage readings for System 2 (Table 1) decrease as the thickness increases while the gage readings for System 5 (Table 3) remain essentially constant as the thickness increases. This strongly suggests that, as the amount of extender pigment increases, there is some concentration where the paint film becomes essentially transparent to beta rays. Thus, when a topcoat with a relatively low effective atomic number is applied over a primer with a high effective atomic number, such as lead pigmented TT-P-25, the topcoat is effectively transparent to beta rays and backscattering occurs only from the primer.

FINDINGS AND CONCLUSIONS

1. A beta-ray backscattering paint film thickness gage for wood can be constructed that is rugged but sufficiently portable for use in the field. This instrument, which includes a counting rate meter for readout, can be calibrated and used successfully in the field for a few specification paint systems for wood.

2. Absorbed moisture in either painted or unpainted wood has essentially no effect on the reliability of the paint film thickness gage readings.

3. Exterior specification paints that contain 40 to 50 percent extender pigments but do not contain any lead pigments are essentially transparent to beta rays. As a result, the paint film thickness gage cannot be used to measure the thickness of this type of paint system.

RECOMMENDATIONS

On the basis of the information presented above, it is obvious that the paint thickness gage does not perform satisfactorily for approximately one-half of the paint systems that are normally used on exterior wooden surfaces at NAVFAC field activities. Because of the serious

limitations this places on the usefulness of the gage for determining the thickness of exterior specification paints, no additional work on gage development is recommended.

Table 1. Paint Film Thickness Gage Readings for Four Paint Systems on Wood.

System No.	Coating System			Calculated Coating Thickness d_i (mils)	Counting Rate, J_d (Proportional counts/min)	Observed Differential Counting Rate (Proportional counts/min)			
	Primer (1 coat)	Finish				TT-P-102 $(J_{max} - J_d)$ $J_{max} = 4564$	TT-P-25 TT-P-0055a $(J_d - J_{min})$ $J_{min} = 1902$	TT-E-545a TT-E-489 $(J_{max} - J_d)$ $J_{max} = 1377$	TT-E-545a Paint A $(J_{max} - J_d)$ $J_{max} = 2129$
		No. of Coats	Type						
1[1/]									
a	None	0	TT-P-102	0	624	3940			
b	"	1	"	2.69	1244	3320			
c	"	2	"	5.6	1864	2700			
d	"	4	"	10.6	2894	1670			
e	"	7	"	18.9	3614	950			
f	"	10	"	25.9	3995	569			
2[2/]									
a	TT-P-25	0	TT-P-0055a	6.8	3302		1400		
b	"	1	"	0.6	3272		1370		
c	"	3	"	4.0	2992		1090		
d	"	6	"	7.6	2702		800		
e	"	9	"	11.6	2402		500		
f	"	9	"	13.5	2287		385		
3[2/]									
a	TT-P-545a	0	TT-E-489	3.3	738			639	
b	"	1	"	1.9	839			538	
c	"	3	"	5.2	932			445	
d	"	6	"	10.4	1088			289	
e	"	9	"	18.3	1237			140	

continued

Table 1. (Cont'd)

System No.	Coating System			Calculated Coating Thickness d_i (mils)	Counting Rate, J_d (Proportional counts/min)	Observed Differential Counting Rate (Proportional counts/min)			
	Primer (1 coat)	Finish				TT-P-102 ($J_{max} - J_d$) $J_{max} = 4564$	TT-P-25 TT-P-005?a ($J_d - J_{min}$) $J_{min} = 1902$	TT-E-545a TT-E-489 ($J_{max} - J_d$) $J_{max} = 1377$	TT-E-545a Paint A ($J_{max} - J_d$) $J_{max} = 2129$
		No. of Coats	Type						
4 2/									
a	TT-E-545a	0	Paint A	2.4	739				1390
b	"	1	"	3.1	964				1160
c	"	3	"	7.1	1250				879
d	"	6	"	14.1	1574				555
e	"	9	"	19.4	1752				377

1/ Wood panels were 4 x 6 x 1/2-inch Douglas Fir.

2/ Wood panels were 4 x 6 x 1/2-inch Ponderosa Pine.

Table 2. Effect of Humidity on Paint Film Thickness Gage Readings

Panel No.	Coating System and Thickness (mils)		Exposure to Moist Air		Ponderosa Pine		Douglas Fir	
	Primer	Topcoat	Days Exposure	% RH	Weight (grams)	Gage Reading [1/]	Weight (grams)	Gage Reading
1	None	None	Initial	Ambient	81.818	525		
			7	25	81.019	525		
			2	50	82.458	540		
			6	80	83.949	540		
			21	80	84.866	55[illegible]		
			46	80	85.255	535		
2	None	None	Initial	Ambient	80.360	530		
			7	25	79.556	515		
			2	50	80.902	530		
			6	80	82.284	535		
			21	80	83.099	540		
			46	80	83.446	555		
3	None	None	Initial	Ambient	81.402	550		
			7	25	80.642	535		
			2	50	81.932	520		
			6	80	83.334	550		
			21	80	84.349	530		
			46	80	84.774	540		
4	1 Coat TT-E-545 2.4 mils	None	Initial	Ambient	84.759	715		
			7	25	83.951	715		
			2	50	83.302	695		
			6	80	86.633	700		
			21	80	87.586	715		
			46	80	87.949	715		

continued

Table 2. (Cont'd)

Panel No.	Coating System and Thickness (mils)		Exposure to Moist Air		Ponderosa Pine		Douglas Fir	
	Primer	Topcoat	Days Exposure	% RH	Weight (grams)	Gage[1/] Reading	Weight (grams)	Gage Reading
5	1 Coat TT-E-545 2.6 mils	None	Initial	Ambient	85.426	710		
			7	25	84.642	705		
			2	50	85.967	705		
			6	80	87.256	695		
			21	80	88.257	700		
			46	80	88.713	715		
6	1 Coat TT-E-545 ~2.5 mils	1 Coat[2/] Paint A 3.0 mils	Initial	Ambient	78.480	945		
			7	25	77.729	955		
			2	50	78.967	935		
			6	80	80.237	925		
			21	80	81.310	955		
			46	80	81.806	910		
7	1 Coat TT-E-545 ~2.5 mils	1 Coat[2/] Paint A 3.2 mils	Initial	Ambient	84.704	1070		
			7	25	83.919	1085		
			2	50	85.220	1040		
			6	80	86.451	990		
			21	80	87.307	1085		
			46	80	87.662	1010		
8	1 Coat TT-E-545 ~2.5 mils	3 Coats[2/] Paint A 6.8 mils	Initial	Ambient	85.274	1220		
			7	25	84.525	1215		
			2	50	85.778	1220		
			6	80	86.920	1175		
			21	80	87.748	1205		
			46	80	88.173	1200		

continued

Table 2. (Cont'd)

Panel No.	Coating System and Thickness (mils)		Exposure to Moist Air		Ponderosa Pine		Douglas Fir	
	Primer	Topcoat	Days Exposure	% RH	Weight (grams)	Gage[1/] Reading	Weight (grams)	Gage Reading
9	1 Coat TT-E-545 ~2.5 mils	3 Coats[2/] Paint A 7.1 mils	Initial	Ambient	86.427	1240		
			7	25	85.694	1203		
			2	50	86.949	1200		
			6	80	88.091	1215		
			21	80	88.945	1205		
			46	80	89.387	1220		
10	None	None	Initial	Ambient			142.934	565
			7	25			141.695	550
			2	50			144.029	570
			6	80			146.102	550
			21	80			147.307	520
			46	80			147.667	575
11	None	None	Initial	Ambient			143.708	565
			7	25			142.452	570
			2	50			144.895	585
			6	80			146.979	570
			21	80			148.305	550
			46	80			148.660	605
12	None	None	Initial	Ambient			145.552	590
			7	25			144.281	560
			2	50			146.978	570
			6	80			149.150	570
			21	80			150.549	550
			46	80			150.919	595

continued

Table 2. (Cont'd)

Panel No.	Coating System and Thickness (mils)		Exposure to Moist Air		Ponderosa Pine		Douglas Fir	
	Primer	Topcoat	Days Exposure	% RH	Weight (grams)	Gage 1/ Reading	Weight (grams)	Gage Reading
13	None	2 Coats 3/	Initial	Ambient			141.541	1435
		TT-P-102	7	25			140.125	1420
		5.3 mils	2	50			142.560	1440
			6	80			144.442	1425
			21	80			145.804	1400
			46	80			146.187	1445
14	None	2 Coats 3/	Initial	Ambient			138.282	1460
		TT-P-102	7	25			136.852	1430
		5.3 mils	2	50			139.241	1445
			6	80			140.994	1410
			21	80			142.222	1375
			46	80			142.590	1440

1/ Gage reading is in proportional counts/min.

2/ Paint A is an acrylic emulsion paint.

3/ The TT-P-102 was self-priming.

Table 3. Gage Readings for Four Specification Paint Systems on Wood[1]

System Number	Coating System	Number of Coats		Total Film[2] Thickness, d (mils)	Gage Reading, J_d (Proportional counts/min)[3]
		Primer	Topcoats		
5 a	TT-P-25 + TT-P-19	1		2.1	1660
b			1	4.2	1605
c			2	7.3	1525
d			3	11.4	1605
e			4	13.5	1615
6 a	TT-P-25 + TT-P-105	1		2.0	1730
b			1	4.3	1750
c			2	7.4	1730
d			3	10.1	1755
e			4	13.1	1785
7 a	TT-P-25 + MIL-P-52324	1		2.6	1660
b			1	5.8	1660
c			2	9.6	1695
d			3	13.0	1735
e			4	15.6	1795
8 a	TT-P-25 + TT-P-102	1		2.2	1680 (2514)[4]
b			1	4.7	2150 (2044)
c			2	7.6	2600 (1544)
d			3	10.3	2900 (1294)
e			4	13.3	3200 (994)

1/ Wooden panels were of Douglas Fir, 4 x 5-3/8 x 1/2-inch in size.
2/ Determined on metal panels with magnetic film thickness gage.
3/ Average of readings from three replicate panels.
4/ Values in parentheses represent observed differential counting rate, $J_{max} - J_d$, where J_{max} = 4194 proportional counts/minute.

Table 4. Type and Percent of Pigments in Specification Paints Used for Calibration Standards

Paint	Percent Pigment								
	TT-P-102	TT-P-25	TT-P-0055	TT-E-545	TT-E-489	TT-P-19	TT-P-105	MIL-P-52324	Paint A
Total by Weight of Paint	62	62	30	35	22	38	59-61	>55	43
White Lead	>31	>50							
Zinc Oxide	25-27						>34	>28	
Titanium Dioxide Anatase	15-17		>9			>17		>21	
Titanium Dioxide Rutile		>12	>81		<100 2/	>40	>23	>7	51
Titanium Calcium				>58					
Barium Sulfate						6			
Barium Meta-borate									26
Mica									7
Extender Pigment 1/	<28	<38	10	<42		37	<43	<44	16

1/ Extender pigments consist of magnesium silicate, aluminum silicate, silica and/or calcium carbonate.

2/ Contains small amount of yellow iron oxide and carbon black to obtain required color.

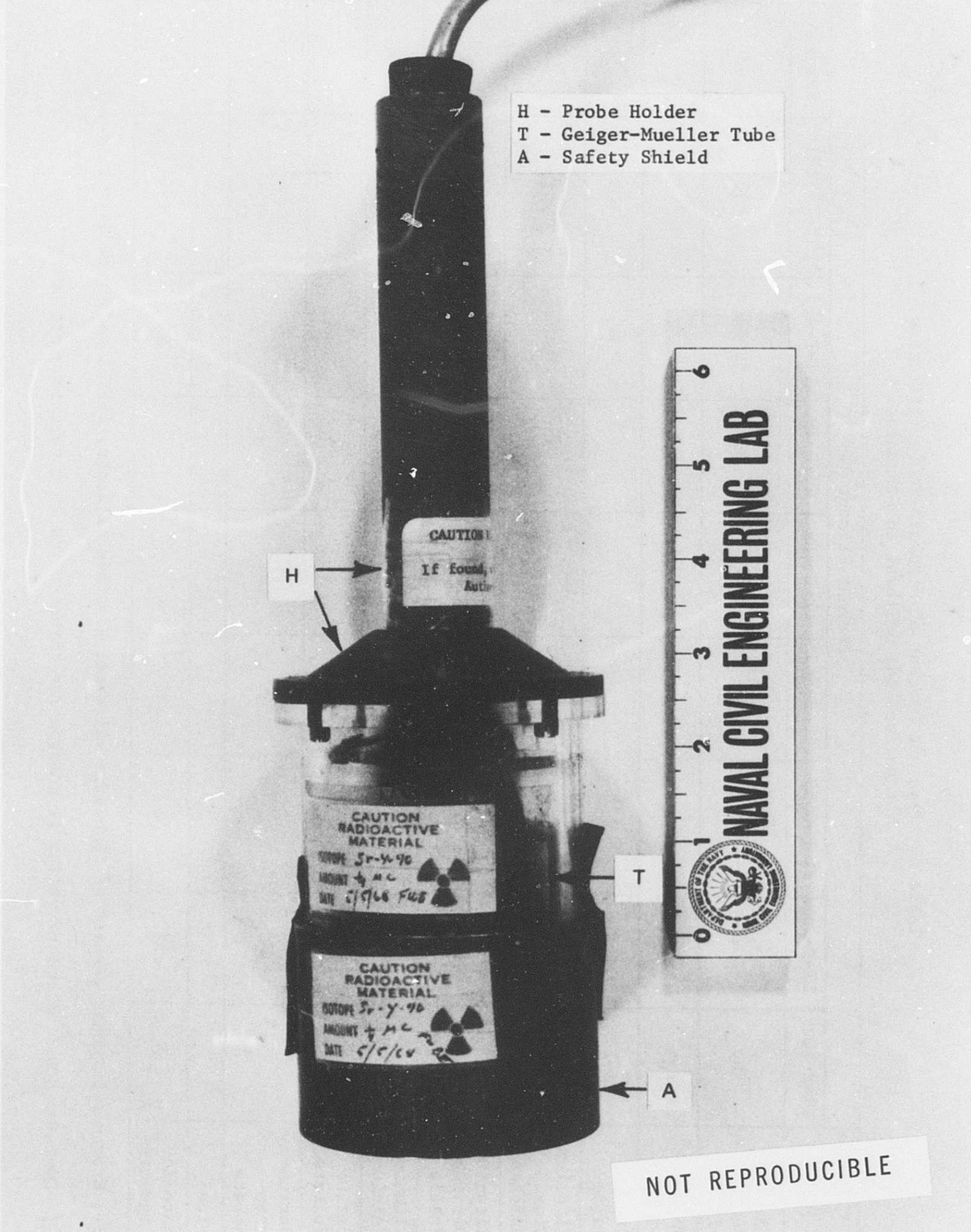

Figure 1. Probe for the portable paint film thickness gage with safety shield attached.

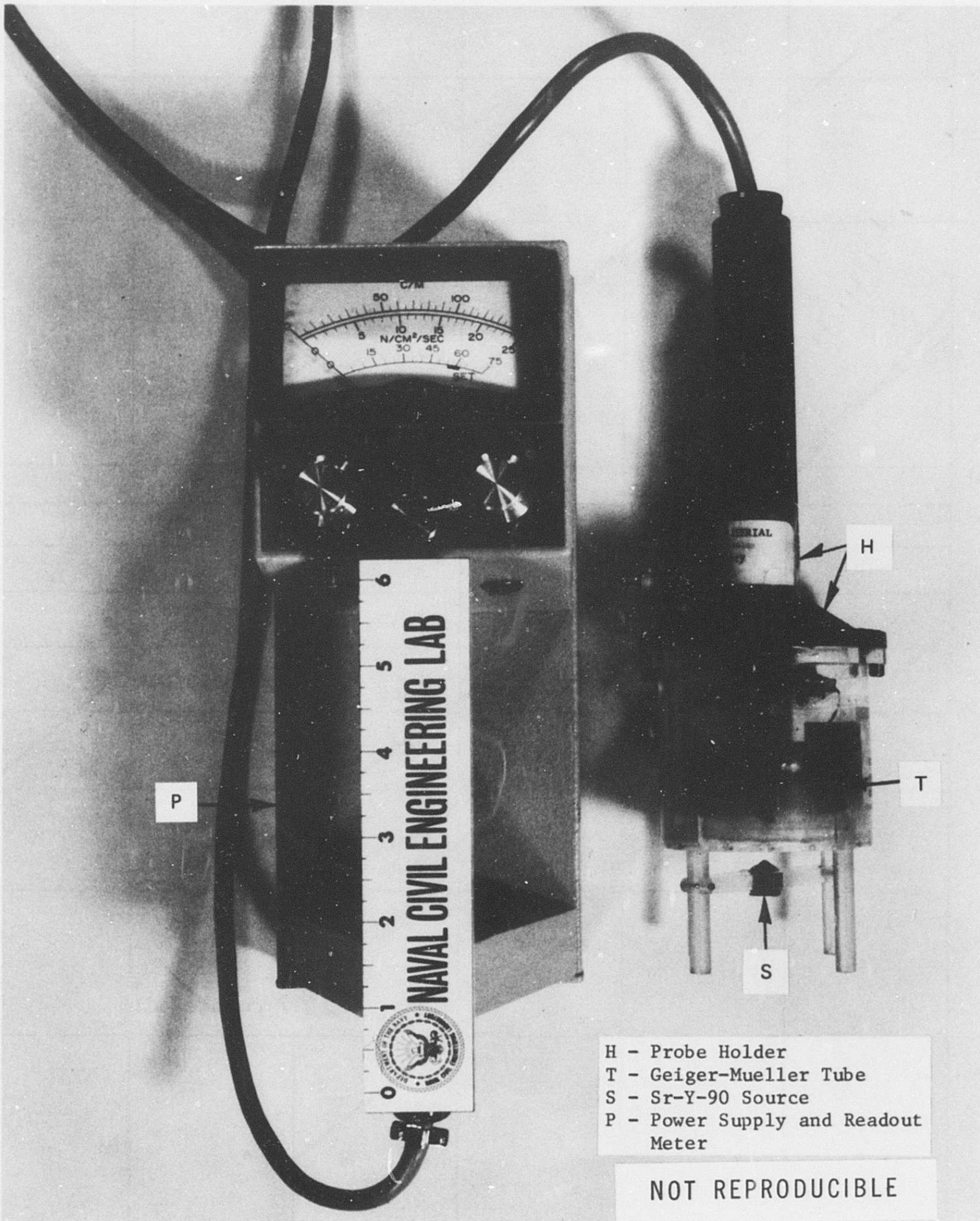

Figure 2. Portable paint film thickness gage (probe attached to thickness gage with safety shield removed).

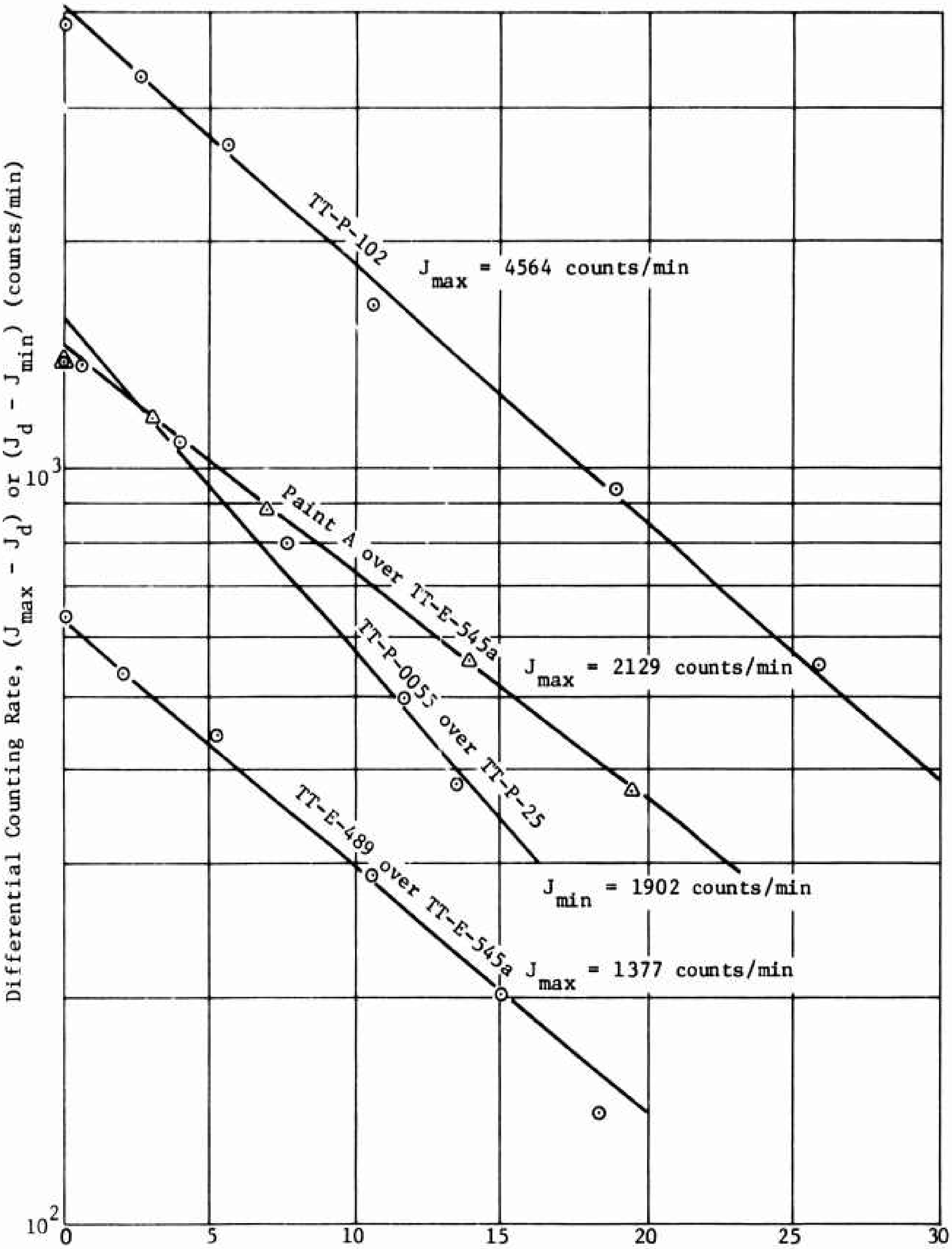

Figure 3. Differential counting rate as a function of paint thickness for several commonly used paints.

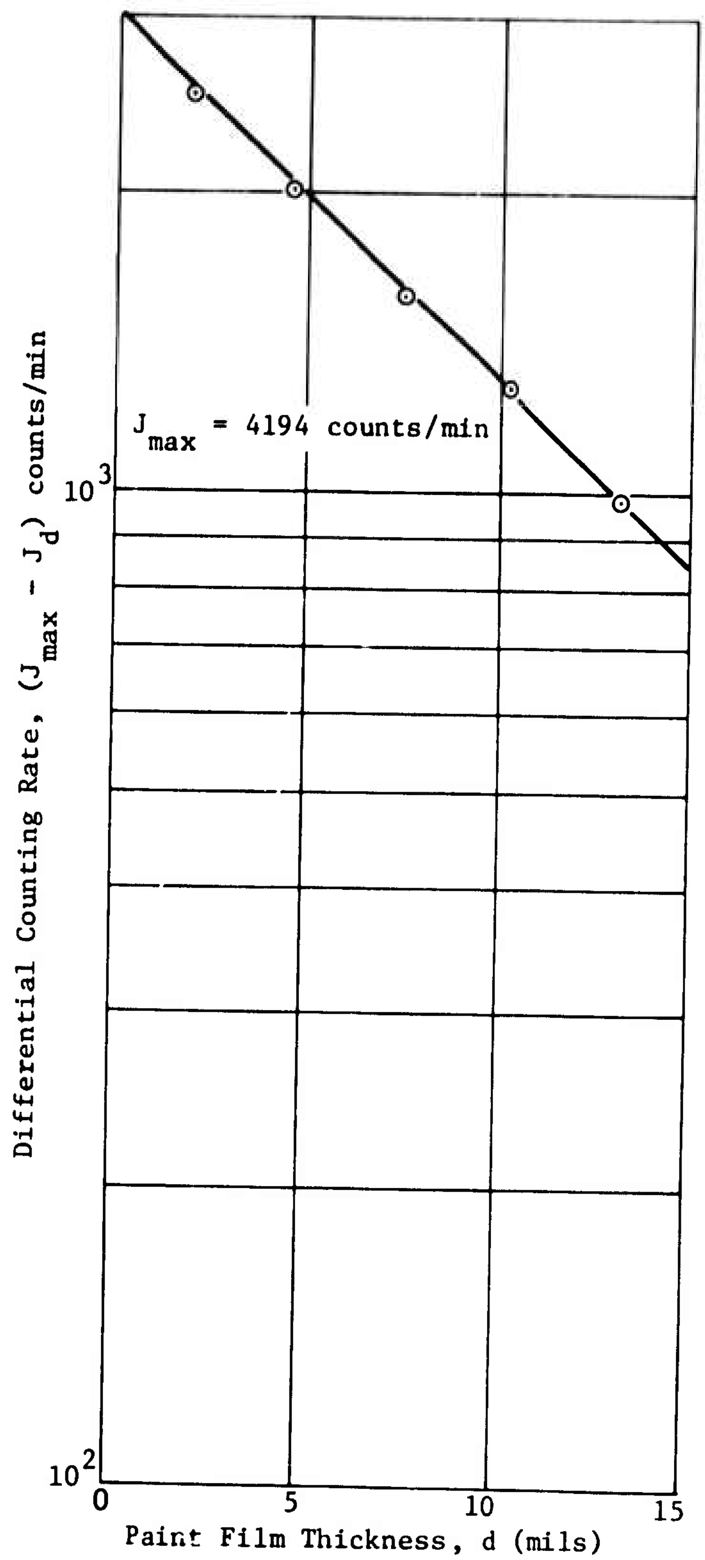

Figure 4. Differential counting rate as a function of paint thickness for paint TT-P-102 over TT-P-25 primer.

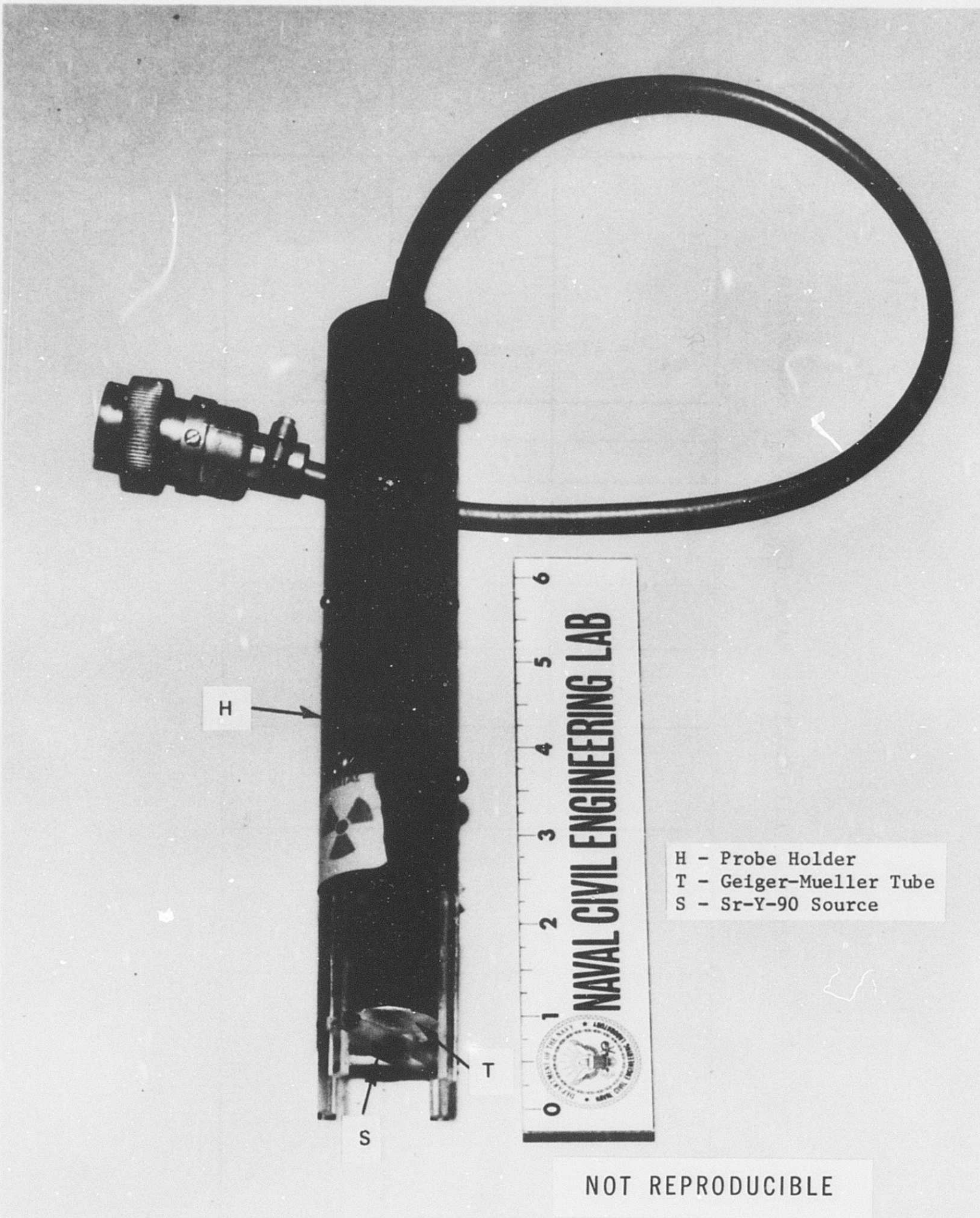

Figure 5. One inch diameter probe for the direct reading paint film thickness gage.

REFERENCES

1. Naval Civil Engineering Laboratory. Technical Note N-847: Measurement of paint film thickness by beta-ray backscattering, by F. W. Brown, III. Port Hueneme, California, Oct 1966.

2. __________. Technical Report R-553: Beta-ray backscattering gage for measuring paint film thickness, by F. W. Brown, III. Port Hueneme, California, Dec 1967.